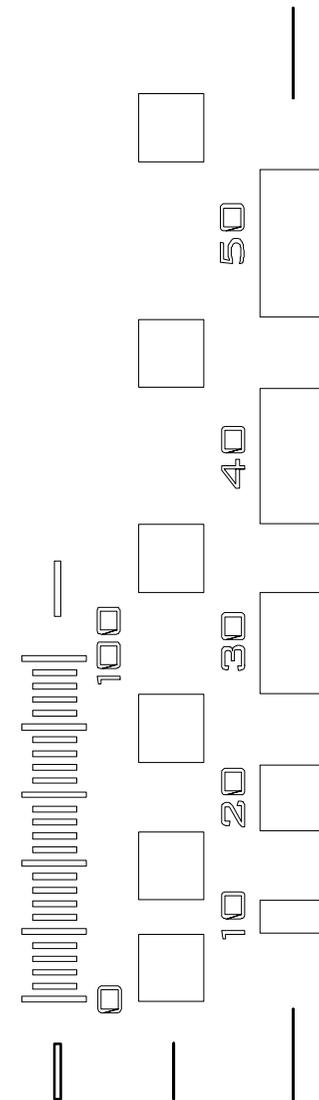# Display Calibrations and Uncertainties

*Christine Wall – National Physical Laboratory*

Overview

- Why measure displays?

- What is measurement uncertainty?

- Measurement traceability NPL and UKAS

- What is an uncertainty, what is an error?

- Calibration of displays at NPL

- Calculating uncertainty budgets for displays

- Sample uncertainty budget

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Why are we measuring displays

SAFETY

↓
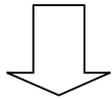
readability

Brightness & contrast

Avoid confusion of symbols

COMMERCIAL

↓

Quality control

Comparison between manufacturers

ASTHETIC

↓

Colour matching

Customer preference

What is a measurement?

Measurements tell us about a property of something. for example, how heavy or long something is. An instrument is needed to make a measurement e.g scales or a ruler.

What is measurement uncertainty?

Uncertainty of measurement is the doubt that exists between the result on the instrument and the true result. It is common to think that a well made clock is "right" but for every measurement even the most careful, there is always an element of doubt. The calculation of measurement uncertainties calculates the amount of doubt in the result.

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Error or uncertainty

Errors, are things that make you measurement wrong, but that you can correct for, where uncertainties cannot be corrected.

There are two types of uncertainties called type A and B:

Type A uncertainties affect the result randomly, so the more measurements you make and average, the closer you will be to the true value

Type B uncertainties affect the result just the same, so by making more measurements you will not get closer to the result. For these you have to estimate the magnitude.

What is a traceable measurement?

To ensure that a bolt bought in Buenos Aires will fit a nut from Norfolk we need to have international agreements on methods of measurement. Hence most countries have a National Metrology Institute (NMI) to hold national standards and ensure that they can trade with the rest of the world.

The NMI's continually compare their measurement techniques, and agree standard methods of working to ensure that their measurements will agree. The NMI's then disseminate their techniques (and test artefacts) to companies and institutes in their own country. For example if you phone BT and set the time on your watch, BT's clock is traceable to NPL's atomic clock, and now so is your watch. Traceable measurements are required by ISO 9001 quality system.

TRACEABILITY means your measurement can be referenced to a national standard.

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Richard the Lionheart, 1196
"Throughout the realm there shall be the same yard of the same size and it should be made of Iron."

700 years later King George V opened the National Physical Laboratory (NPL), which is the United Kingdom's NMI.

NPL maintains the national measurement system by holding national standards, These used to be physical a metre, a kilogram, but now are more often electrical or frequency based.

Measurement is hard to avoid: your clothes come in agreed sizing, your food is measured for contaminants and weight, petrol volume, computer chip timing, electricity units, weather forecasting, TV's have 200+ measurements in manufacturing…

Many measurements in the UK are traceable to NPL, and hence international standards

www.npl.co.uk

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UKAS

So NPL maintains the national measurement system, but we cant ensure every measurement is traceable to NPL… which is where the United Kingdom's Accreditation Service UKAS come in….

UKAS test the ability of companies, or other bodies to perform measurements accurately, and traceably to national standards. If they are, it provides an accreditation mark… this is comparable to the kite mark for safety of products.

UKAS is the sole national body recognised by government for the accreditation of testing and calibration laboratories, certification and inspection bodies. It is a not-for-profit company operating under a Memorandum of Understanding with the government through the Department of Trade and Industry

The UKAS website can tell you if a lab is accredited, or where your nearest UKAS accredited lab is, you can guarantee that the measurements from a U____ be accurate to within the uncertainty they quote.
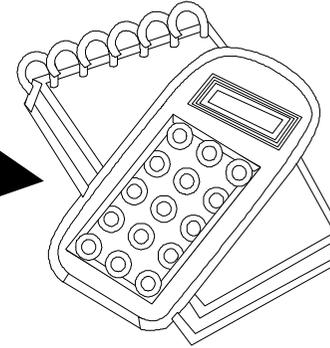
www.UKAS.co.uk

Current technique for display calibration
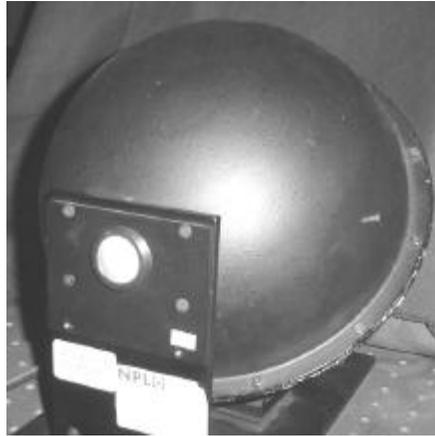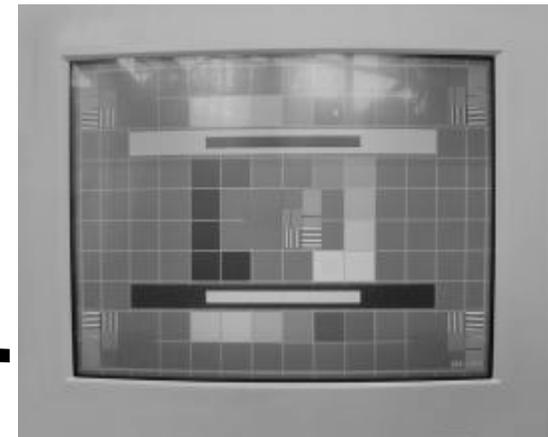
2. Measure a stable well characterised light source (calibrated by a UKAS accredited lab)

3. Make a correction file

5.Apply correction file to find calibrated result

4. Measure display

1. Select the instrument

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The Contributions to Uncertainty

Measurement instrument:
1. Wavelength uncertainty (monochromator, filters)
2. Stray light inside the instrument
3. Linearity of detector
4. Polarisation sensitivity of system (grating, optics, detector)
5. Chromatic aberration due to lenses (?)
6. Temperature sensitivity of detector

Secondly there are effects due to the room of the test namely:
7. Stray light in the room (not from item under test) reaching the detector

Thirdly the method of calibration (i.e. using a calibrated light source)
8. Inherited uncertainty from calibration
9. Output uniformity (position and angle, check alignment capability)
10. Output stability of lamp (check current stability using standard resistor)

Finally:
11. Repeatability of the measurement

Uncertainty budget (luminance)

Source of Uncertainty Luminace %	Type A or B	Limiting value ± %	Probability distribution	Divisor	u_1	v_i or v_{eff}
Inherited lamp uncertainty [1]	B	2.0	normal = 2	2	1.00	∞
Lamp uniformity[2]	B	1.0	normal = 2	2.00	0.50	∞
Linearity[3]	B	0.0	-	-	0.00	∞
Bandwidth[4]	B	0.3	rectangular = √3	1.73	0.17	∞
Wavelength[5]	B	2.4	rectangular = √3	1.73	1.39	∞
Repeatibility[6]	A	0.8	normal = 1	1	0.80	5
Combined Uncertainty			normal		1.72	
Expanded Uncertainty			normal (k=2)		3.45	%

Summary

1) Think about what you want to measure
2) Consider anything that can affect the result, and list them
3) Where possible measure the effect to find the uncertainty
4) Calculate the uncertainty budget
5) Quote the result AND the uncertainty

Still not sure:

For the weak hearted read "A beginners guide to uncertainty of measurement" by Stephanie Bell from NPL….

Not weak hearted? Try reading "M3003- The uncertainty of measurement" from UKAS. www.ukas.co.uk

This is the definitive guide.

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